

REMARKS

The above-amendments and the corrected Terminal Disclaimer accompanying this Amendment are believed to place this case in condition for allowance.

The Specification has been amended to cancel the term "saturated". This term has also been removed from all the claims. Dodecyl in Claim 21 has been corrected.

Claim 6 has been amended to incorporate all the limitations of allowable Claim 7. Claims 8-9 depend from allowable Claim 6.

Claim 1 has been amended to recite that the cross-link is an alkylene chain containing 6 to 12 carbon atoms. This is the same scope as the separator defined in the allowable amended Claim 6 directed to a battery. The reason for allowance stated by the Examiner are equally applicable to Claim 1. Claims 2-5 and 21, depend from allowable Claim 1.

Method Claims 10 has been amended to recite that the cross-linking agent is an alkylene polyhalide containing 4 to 16 carbon atoms.

The only claim rejected is Claim 6. Claim 6 is rejected under 35 USC 103 as being unpatentable over SU 651,346 in view of Klug (3,754,877). SU 651,346 is allegedly cited for a teaching of a cross-linked cellulose separator in a silver-zinc alkaline battery.

However, the Derwent Abstract attached to the patent states that the Ag-Zn accumulator is coated with 3-4 layers of hydrated cellulose from a solution containing strongly cross-linked

cellulose xanthogenate. The cellulose xanthogenate reacts with CO₂ in air to yield free acid and the latter decomposes into CS₂ and cellulose hydrate. The layer formed is 10-60 microns thick and adheres firmly to the electrode surface.

The cellulose xanthogenate is highly cross-linked. There would be no reason to search for a method to increase cross-linking. Regenerating is not an issue since the cellulose hydrate coating is firmly adhered to an Ag-Zn electrode surface. Furthermore, the separator or coating is cellulose hydrate not a cross-linked cellulose xanthogenate.

The Examiner is taking a parameter first disclosed in Applicant's Specification (rigidly) to create a reason to look for a secondary reference disclosing a similar cross-linking reaction. However, Klug uses cross-linked cellulose as a gelling agent for a fuel. Totally unrelated field and irrelevant to the invention.

For the above reasons this application is believed to be in condition for allowance and such action at an early date is respectfully solicited.

Respectfully submitted,



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cellulose solution containing cellulose having a degree of polymerization between 200 and 1200 is crosslinked with a ~~saturated~~ hydrocarbon group containing 4 and 16 carbon atoms and said cellulose solution is coagulated to produce a gel that upon dehydration yields a film operable as a battery separator. This separator has higher mechanical strength than uncrosslinked separators.

Detailed Description of the Invention

The present invention disclosed a battery separator that improves on the native strength of regenerated cellulose and is more resistant to oxidation than regenerated cellulose. The invention proceeds by crosslinking dissolved cellulose and forming a film from this crosslinked cellulose.

Cellulose, with a degree of polymerization from 200 to 1200, in the form of, but not limited to, microcrystalline cellulose, cotton fiber, paper and microgranular cellulose, is dissolved using a variety of different solvents, including, but not limited to, LiCl/DMAC, trifluoroacetic acid and N-morpholine N-oxide. With LiCl/DMAC, the preferred range is 3 to 8% wt LiCl to DMAC and the applicable range for the percent weight solution of cellulose to solvent is 1 to 11%.

After dissolving the cellulose, the hydroxyl groups on the cellulose are deprotonated by adding an amount of a base, in particular an inorganic hydroxide such as NaOH. The base is added in sufficient quantity to deprotonate just a small fraction of available hydroxyls, usually 1 to 10%, for an excess would result in side reactions causing chain cleavage with consequent depolymerization and degradation in film strength.

After the deprotonation is complete, a dihalide containing 4 to 16 carbon atoms is introduced into the reaction vessel, preferably an alkylene dehalide containing 4-12 carbon atoms. The dihalide reacts with deprotonated sites on adjacent cellulose chains to form ~~saturated~~ hydrocarbon cross-link groups. The cross-link reaction preferably conducted at temperatures from 55 to 90 degrees Celsius for periods ranging from 8 to 24 hours. The amount of dihalide added is the gram-equivalent to all of the hydroxyls available. The NaOH is allowed to settle and the solution is then cast via conventional methods. These methods are known to those skilled in the art of membrane fabrication. They include extrusion of the solution onto a conveyor belt, casting onto a glass plate with a casting knife or casting onto a well-leveled glass plate to form a separator having a thickness from 10 microns to 250 microns.

After casting, the resulting solution is coagulated with conventional techniques, preferably using water as the coagulating agent. Coagulation may be attained either by exposure to ambient moisture or by direct application of a water stream to the resulting solution. The coagulated cellulose material is washed to remove the solvent and the salt. It is possible to employ alcohols mixed with water, but it is preferable that they be kept below 50% by volume.

After thorough washing of the resulting gel, the gel may be dried with any conventional technique such as air drying, vacuum drying or press drying.

Example 1

100 g of LiCl is dissolved in 2 kg of dimethylacetamide (DMAC) at room temperature. 40 g of microcrystalline cellulose (MCC, Aldrich 31,069-7) is placed in a solution containing 2.1 kg of LiCl/DMAC solvent and heated to 120 degrees Celsius for 15 minutes. The